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PROPOSED METHODOLOGY FOR MULTIPLE FRAGMENT WOUND ASSESSMENT USING THE ARRADCOM COMPUTER MAN

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This report describes a proposed methodology for multiple fragment wound assessment using the ARRADCOM Computer Man.

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PREFACE

The work described in this report was authorized under Project 1L162622A554, Chemical Munitions and Chemical Combat Support, Task Area 6, Bioresponse to Trauma, and Project 1L162618AH80, Ballistics Technology, Multiple Wounding Task. This work was started in June 1978 and completed in June 1979.

PROPOSED METHODOLOGY FOR MULTIPLE FRAGMENT WOUND ASSESSMENT USING THE ARRADCOM COMPUTER MAN

I. INTRODUCTION.

Recently Biophysics Branch personnel completed the MIMIC phase of the ARRADCOM Computer Man which permits computer determination of the incapacitation level of an infantry soldier due to a single fragment wound.

In the last year, Biophysics Branch has received many inquiries regarding the possibility of using the Computer Man to assess wounds resulting from multiple fragments. This brief report describing a proposed methodology for assessing such wounds is being circulated to receive comments from users with current requirements for multiple wound assessments; to acquaint potential users with the basic capabilities; and to precipitate discussions for adapting the methodology to newly defined requirements.

II. PROPOSED METHODOLOGY FOR MULTIPLE FRAGMENT WOUND ASSESSMENT USING THE COMPUTER MAN.

Current incapacitation estimates, $P(I|H)$, are reported for six body components: head and neck, thorax, abdomen, pelvis, upper extremities, and lower extremities. Total body $P(I|H)$, which involves appropriate summing of these six component values, has also been a required value.

All of these $P(I|H)$ values are based on limb dysfunction, which is graded into three categories: no dysfunction (always 0% incapacitation), loss of fine coordination, or loss of coarse (complete) coordination. The percent incapacitation associated with partial or complete loss of function depends on the tactical role and time after injury; that is, the present incapacitation varies according to scenario (required biomechanics).

We are proposing to extend the computer man methodology to provide biomechanical degradation outputs explicitly and to account for multiple wounds from either a single fragment or several fragments.

Biomechanical degradation is characterized by the degree of limb dysfunction, which depends on the location and size of the wound. Currently, functional groups are used to specify the degree of limb dysfunction (none, loss of fine coordination, total dysfunction) of the arms and legs. (We are in the process of refining the definition of loss of fine coordination based on a review of the previous assessment methodology and discussions with our medical consultants.)

The functional groups developed in a computer man projection depend on the fragment mass, density, shape, and velocity, and on the time after wounding, but they are not dependent on the role of the soldier. Therefore, our intention is to produce an output which is a set of ordered pairs

$$F_p = \{(F_i, p_i);\ 1 = 1,\ldots,n\} \tag{1}$$

where each F_i is a functional group and p_i is the probability of occurrence of F_i. The vector

$$P = (p_1, p_2,\ldots,p_n) \tag{2}$$

will be called a functional group vector. This vector, of course, also depends on the fragment parameters, body part, and time after wounding but it is not dependent on the tactical role of the soldier.

This methodology will include the ability to combine functional groups associated with multiple wounds along a single wound tract and to distinguish dysfunctions to left and right arms and legs (capabilities not available in the existing Computer Man methodology).

The outputs will be body part and total body functional group probability vectors for a family of fragments.

To make a conversion for a particular tactical role, R, one must assign an incapacitation probability (or percent degradation), $P_R(I;F_i)$ to each F_i. The incapacitation probability due to random hits on the body part is then computed as:

$$P_R(I) = \sum_{i=1}^{n} p_i P_R(I;F_i) \qquad (3)$$

It is important to emphasize that, using this approach, one need not reproject fragments for every new role, since the functional group probability vectors, which are the outputs of the computer projection, are role independent.

To account for multiple wounds, we propose the following methodology: We need to define a matrix $(F_i \circledast F_j)$* which will reflect combined functional groups. The entry appearing in the (i,j) position of the matrix is the functional group F_k resulting from combining F_i and F_j.

In the notation of equation 1, suppose the output for fragment 1 for body part A is:

$$F_r = \{(F_1, r_1) ,\ldots, (F_n, r_n)\} \qquad (4)$$

and the output for fragment 2 for body part B is:

$$F_s = \{(F_1, S_1) ,\ldots, (F_n, S_n)\} \qquad (5)$$

Then the result of combining fragments 1 and 2 is the output:

$$F_r \circledast F_s = \{(F_1, t_1) ,\ldots, (F_n, t_n)\} \qquad (6)$$

where

$$t_k = \sum_{(i,j) \text{ in } D} r_i\, s_j \qquad (7)$$

* This task requires some additional medical assessments and is currently underway.

and

$$D = \text{the set of all } (i,j) \text{ pairs so that} \quad F_i \otimes F_j = F_k \tag{8}$$

To obtain the functional group vector P for the entire body, we first write $t_i(A,B)$ to emphasize the explicit dependence of t_i on body parts A and B. Then the components p_i of P are given by:

$$p_i = \sum_{(A,B)} P(A,B)\ t_i\ (A,B) \qquad (i = 1, 2, \ldots, n) \tag{9}$$

where

$$P(A,B) = \text{the joint probability of hitting body part A with the first fragment and body part B with the second fragment.} \tag{10}$$

The summation in equation 9 above is carried out over all body part pairs; that is, over AA, AB, AC,..., BB, BC,..., and so on.

The procedure may be iterated to account for additional fragments. After all fragments are accounted for and the final components p_i of P have been developed, the resultant incapacitation probability due to these multiple hits is then computed by equation 3 above.

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